The value of macroinvertebrate assemblages for determining priorities in wetland rehabilitation: A case study from Lake Toolibin, Western Australia.

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Abstract

The use of macroinvertebrates in environmental assessment is well known, but is often perceived as costly and time-consuming. Using preliminary macroinvertebrate and associated salinity data recorded at Lake Toolibin and adjacent wetlands, we discuss the salinization process and how observed faunal assemblages might be used to assess a rehabilitation program. Ninety taxa were collected from two sampling occasions, most of them being saline-tolerant forms representing widespread groups with high dispersive powers. Predominantly freshwater forms not found, but expected to occur, can be used as indicator taxa for recovery. In addition to the need for regular monitoring of the fauna, we argue for a greater emphasis on ensuring the recovery of Lake Walbyring, which contained a demonstrably different suite of macroinvertebrates.

Introduction

Lake Toolibin, approximately 200km south-east of Perth, lies at the head of a series of seasonal or ephemeral lakes which form the headwaters of the Arthur River, a tributary of the Blackwood River in south-western Australia. The clearing of native vegetation has resulted in both a rise in saline groundwater levels and an increase in saline surface run-off into the headwaters of the Arthur River (Halse 1988). Most wetlands of the system, and other parts of the Western Australian wheatbelt, have been severely affected by secondary salinization. However, Lake Toolibin has remained comparatively fresh.

Lake Toolibin Nature Reserve is a registered "Wetland of International Importance" under the Ramsar Convention. It has important conservation value as a breeding habitat for native waterfowl, including rare species (Halse 1987), and because of the occurrence of restricted vegetation types (Froend *et al.* 1987). The Department of Conservation and Land Management of Western Australia and the local Lake Toolibin Catchment Committee are engaged in tree planting and overland flow interception and diversion operations in the Lake Toolibin catchment in an effort to prevent any further decline of this Reserve. Recent efforts to monitor these restorative activities include the work of Bell & Froend (1990), who recorded the decline and mortality of wetland trees at Lake Toolibin over a five year period. The recovery plan for Lake Toolibin (Anon. 1992) suggested that aquatic invertebrate surveys should be undertaken to provide a measure of water quality, and to indicate whether recovery criteria were being met.

Faunal composition should show a rapid response to changing wetland conditions because many macroinvertebrate taxa possess a mobile phase in their life cycle, hence they can colonize suitable habitats rapidly. In the case of Lake Toolibin, the hypothesis is that water salinity will largely dictate the type of fauna that will be found. While the "coarse relationship" (*sensu* Williams *et al.* 1990) between salinity and faunal composition is unquestionable, the role of salinization in shaping aquatic communities remains poorly understood (De Deckker 1983). The work of Williams *et al.* (1991) suggested that Australian macroinvertebrates are more tolerant to salinity than previously thought, although an alternative explanation is that only euryhaline forms persist from a once more diverse fauna.

At Lake Toolibin, neither the structure of aquatic invertebrate communities, nor the possible effects of increasing salinity on them, have been described. Baseline data are therefore necessary if we are to understand what is happening in this wetland. If macroinvertebrate assemblages are to be used as indicators for monitoring restorative change, then ideally sampling should be simple to perform (perhaps by relatively untrained people), and yield results upon which rehabilitation endpoints can be determined.

The aim of this paper is to provide a preliminary assessment of macroinvertebrate data for Lake Toolibin and adjacent wetlands as the basis for monitoring a rehabilitation programme.

Lake Toolibin Case Studies

The Lake Toolibin district had a higher than average rainfall (404 mm *cf* 358 mm) in 1992. In late September of that year, students and staff from Edith Cowan University (Joondalup) visited six sites, covering each of three major water bodies and the major habitats in the Toolibin district (Fig 1).

Water conductivity (in mS cm^{-1}) was measured at each site using a Wissenschäftlich-Technische Werkstätten conductivity meter. The measurements were converted to parts per thousand (ppt) by multiplying the value by 0.6, following Williams (1966), in order to provide comparative data to Halse (1987).

At each sampling site, recognizably different microhabitats were sampled for macroinvertebrates using a standard Freshwater Biological Association net of 500µ mesh size. The sampling technique involved vigorously sweeping the water column from water surface to sediments over an area of approximately one square metre. Material collected was then live-picked, with representatives of morphospecies being preserved in 70% alcohol for later identification in the laboratory. A drift net (DN) with an opening of 300 mm x 330 mm and mesh size of 500 µm was set for 24 hours in the Arthur River (upstream from site 1) to collect macroinvertebrates. Material collected (approximately 2 litres of invertebrates) was mixed and halved to reduce sample size, then preserved in 5% formalin and subsequently sorted in the laboratory. Zooplankton was sampled at each site by towing a 63 µm mesh size zooplankton net for 5 m in approximately 0.3 m of water near the shore. Material collected was preserved in 5% formalin and subsequently sorted in the laboratory. All collections of invertebrates were identified to species level wherever possible, with adults and larvae being treated as separate taxa.

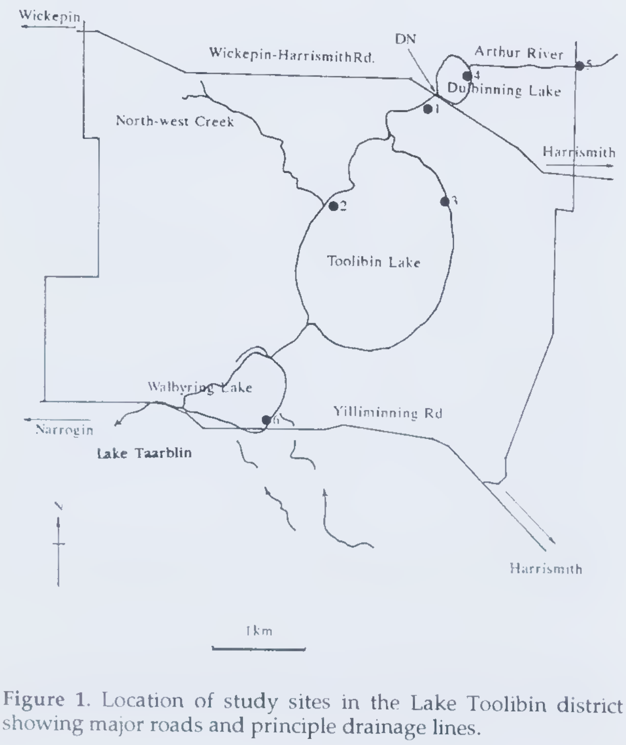

Figure 1. Location of study sites in the Lake Toolibin district showing major roads and principle drainage lines.

To examine seasonal changes and the effects of evapo-concentration, the sites were revisited by RGD in mid April 1993. Only Lake Walbyring (site 6) was resampled as before, as the other sites were dry.

Table 1 summarizes the salinity, species richness and the number of species found exclusively at each site (*i.e.* site-specific species). During the September sampling, Lake Toolibin and the three upstream sites had a salinity of 2.4-4.4 ppt, which is about one-tenth that of seawater. At this time, the salinity at Lake Walbyring was less than half the concentration found at other sites, and was the only site with "fresh" waters (where fresh might be regarded as <1.6 ppt after converting the salinity boundaries provided by Semeniuk, 1987). Whereas other sites became dry and salt encrusted over summer, Lake Walbyring in April 1993 still had a salinity below that of Lake Toolibin when it was full in September 1992.

Table 1.

Salinity and macroinvertebrate species richness at Toolibin district lake sites.

Site	Location	Salinity mS cm^{-1} (ppt)	Species Richness	Site-Specific Species
1	Arthur River	5.8 (3.5)	33	8
DN	Drift net	(see above)	29	6
2	Lake Toolibin (Western side)	5.0 (3.0)	25	2
3	Lake Toolibin (Eastern side)	4.0 (2.4)	26	3
4	Lake Dulbinning	5.8 (3.5)	31	6
5	Shallow marsh area	7.3 (4.4)	20	3
6	Lake Walbyring	1.7 (1.0)	31	14
6[a]	Lake Walbyring	2.6 (1.6)	27	0

[a] indicates April 1993 data.

A total of 90 macroinvertebrate taxa (82 of which were found in the September 1992 samples, and 27 in the 1993 sample) were recorded from the study (Appendix 1). Most of the major inland aquatic orders of invertebrates were represented. Some notable absences from the aquatic fauna were the mayflies (Ephemeroptera) and stoneflies (Plecoptera). These groups are among the insect orders thought to be sensitive to salinity levels greater than about 1.0 ppt (Hart *et al.* 1991). Lake Walbyring contained substantially more site-specific species than any other site (Table 1).

Discussion

Degradation of Lake Taarblin, immediately downstream of Lake Walbyring, became obvious in the 1930s when the death of wetland trees was thought to be due to the rise in water levels (Anon. 1987). According to Sanders (1991), salinization of Lake Taarblin was thought to have begun in the late 1950s, with Lakes Toolibin, Dulbinning and Walbyring following a similar pattern in the 1960s. Along with this historical pattern is a seasonal variability in salinity with lake waters becoming more saline as they become shallower (through evapoconcentration), and a tendency for salinities to vary interannually, presumably as a result of annual rainfall variations and the occasional flushing of salt when lakes overflow (Halse 1987).

We know that the rainfall received in 1992 was above average and that the lakes of the Toolibin district contained water for longer than normal. Similarly, September sampling reflects wetter conditions and lower salinities compared to other times of the year. For both these reasons, our data should represent the "fresher" end of the values collected recently for these wetlands. However, historical depth and salinity data of Lakes Toolibin and Walbyring collected by the Department of Conservation and Land Management (JAK Lane, unpub. data) show the reverse pattern. Salinities for Lake Toolibin were higher in 1992 than they were in 1983 or 1990, the two other years in which the lake was full of water. Over this period, Lake Walbyring was consistently fresher than Lake Toolibin, and does not seem to have had as strong a trend toward salinization, as we also found.

The hydrology and hydrogeology of the Toolibin area is complex; however, Lake Walbyring does appear anomalous, with comparatively fresher waters than the other lakes, when full. Lake Toolibin is thought to be a groundwater recharge area, where waters enter a shallow, saline aquifer beneath the lake. Stokes & Sheridan (1985) believe these waters realize superficial expressions at Lake Walbyring and the severely salt-scalded Lake Taarblin, with Lake Walbyring receiving overflow from Lake Toolibin at over bank-full stage. It is unclear how the waters of Lake Walbyring are being maintained, especially in its comparatively freshwater state. Perhaps the lacustrine deposits are creating a "perched" effect, and/or this waterbody receives run-off from part(s) of a catchment that are less salt-affected than those drainage lines which supply other wetlands of the system.

The aquatic macroinvertebrate taxa found at Lake Toolibin and adjacent wetlands are predominantly euryhaline forms typical of brackish/slightly saline habitats, and most have wide dispersive powers. The relative dissimilarity of the Lake Walbyring fauna may imply that this wetland has retained fresher elements otherwise lost due to the salinization of the Lake Toolibin area. Alternatively, faunal assemblages may be seasonally opportunistic with respect to salinities. In wetlands that experience fluctuations in salinity, there may be a succession of species as salinities change. For instance, unpublished data (S Halse, *pers. comm.*) taken at Lake Walbyring in September 1985 and August 1986 (when salinities were far greater) show a fauna much more tolerant of saline conditions; 28 taxa were found on these two sampling occasions, yet no more than one third of these taxa were found by us at Lake Walbyring. No Ephemeroptera or Plecoptera, were found in any collections.

As with many biological surveys, our interpretation of the data is based on a "snapshot" sampling regime, and some caution is required. Nevertheless, the magnitude of the differences between the fauna of Lake Walbyring and Lake Toolibin, apparently related to differences in salinity, suggest that a single macroinvertebrate collection by relatively untrained, but supervised personnel, can yield valuable baseline data. Any remaining ambiguities, like those discussed above, could be resolved best through the longer term monitoring and detailed analyses of macroinvertebrate assemblages. Monitoring over time would be required to document the full range and seasonality of species, and determine whether a more regional, less cosmopolitan fauna becomes established as tree-planting and hydrological manipulations have effect.

We propose that the faunal characteristics at Lake Walbyring found in September 1992 could be the minimum required to indicate successful rehabilitation if consistently found at Lake Toolibin; other fauna like mayflies (Ephemeroptera) could also be indicators of wetland recovery from saline effects. Furthermore, the fresher waters of Lake Walbyring are a habitat for potentially re-colonizing species and should be monitored.

The production of these preliminary findings are timely, given that decisions regarding water and salinity management at Lake Toolibin are imminent. Engineering solutions, including water diversion measures, may be the only short-term method of saving Lake Toolibin, yet our results indicate that in a wetland chain, one lake cannot be treated in isolation from neighbouring wetlands, and that a greater understanding of catchment conditions at least at Lake Walbyring, is required. Decisions about rehabilitating Lake Toolibin should not exclude the value of Lake Walbyring or any other regional wetland which may, at one time or another, harbour an assemblage of freshwater species.

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Appendix 1.

Invertebrate taxa found in the Northern Arthur River wetlands. (For explanation of site codes, see Table 1 and Figure 1).

PHYLUM CLASS (ORDER) Family	Species	Site 1	DN*	2	3	4	5	6	6[a]
PLATYHELMINTHES	Sp	X						X	
NEMATODA	Sp	X							X
ANNELIDA									
OLIGOCHAETA	Sp1	X							
	Sp2							X	X
	Sp3					X			
HIRUDINEA	Sp	X			X		X		X
ARTHROPODA									
ARACHNIDA									
(ACARINE)	*Eylais* sp		X						
	Limnesia sp							X	
(ARANEAE)	*Singotypa* sp							X	
Tetragnathidae	*Tetragnatha* sp							X	X
CRUSTACEA									
(NOTOSTRACA)	*Lepidurus apus viridis* Baird						X		
(CLADOCERA)									
Chydoridae	*Pleuroxus* sp	X		X	X				
Daphniidae	*Ceriodaphnia* sp		X			X	X	X	
	Daphnia carinata King	X	X	X	X	X		X	X
	Simocephalus sp	X	X			X	X		
Macrothricidae	*Echinisca* sp	X		X		X	X		X
	Macrothrix ?breviseta Smirnov						X		
Moinidae	Sp	X	X		X			X	X
(OSTRACODA)									
Cypridacea	*Cyprinotus ?edwardi* McKenzie	X	X	X	X	X		X	
	Diacypris spinosa De Deckker	X							
	Mytilocypris ?ambiguosa De Deckker	X	X	X	X	X		X	
	Mytilocypris sp 2		X	X	X	X			
	Alboa worooa De Deckker	X	X	X	X	X	X		
	Bennelongia sp	X			X				
	Sarscypridopsis aculeata (Costa)	X		X	X		X		
(CHONCHOSTRACA)	*Cyzicus* sp	X							
(COPEPODA - Calanoida)									
Centropagidae	?*Calamoecia* sp	X	X	X				X	X
(COPEPODA - Cyclopoida)	?*Microcyclops* sp	X		X		X	X	X	
(AMPHIPODA)									
Ceinidae	*Austrochiltonia* sp	X	X	X	X	X	X	X	
(DECAPODA)									
Palaemonidae	"*Palaemonetes australis*" Dakin	X				X	X		
Parastacidae	Claw of *Cherax albidus* Clark	X							
INSECTA									
(ODONATA - Anisoptera									
Aeshnidae	*Hemianax papuensis* (Burmeister)							X	X
(ODONATA - Zygoptera)									
Coenagridae	*Xanthagrion erythroneurum* (Selys)							X	
Lestidae	*Austrolestes annulosus* (Selys)							X	X
	Austrolestes io (Selys)					X			
(HEMIPTERA)									
Corixidae	?*Agraptocorixa* sp								X
	Micronecta sp1								X
	Micronecta sp2								X

Appendix 1 (continued)

PHYLUM CLASS (ORDER) Family	Species	Site 1	DN*	2	3	4	5	6	6[a]
	Sigara sp		X	X		X		X	
	Sp5								X
Notonectidae	*Anisops* sp1		X	X	X			X	X
	Anisops sp2							X	X
	Paranisops sp	X		X		X		X	X
	Sp4		X			X		X	
(DIPTERA)									
Chironomidae	*Chironomus aff. alternans* Walker					X			X
	Chironomus tepperi Skuse	X	X	X	X	X	X		
	Cryptochironomus griseidorsum Kieffer				X				
	Dicrotendipes conjunctus Walker					X			
	Kiefferulus intertinctus Skuse								X
	Procladius paludicola Skuse		X			X	X		X
	Procladius villosimanus Kieffer					X			
Ephydridae	Sp			X					
Ceratopogonidae	Sp							X	
Culicidae	*Anopheles* (*Cellia*) sp					X			
	Culex sp1							X	
	Culex sp2			X					
Tabanidae	Sp							X	
Unidentified Dipteran Pupae	Sp1		X	X	X	X			X
	Sp2							X	
	Sp3			X					X
(TRICHOPTERA)									
Leptoceridae	*Triplectides australis* Navas								X
(COLEOPTERA)									
Dytiscidae (larvae)	*Antiporus* sp	X	X	X	X	X	X		
	Bidessus sp1		X		X				
	Bidessus sp2				X				
	Homeodytes scutellaris (Germar)		X						
	Hydaticus sp1	X	X	X		X		X	
	?*Hydaticus* sp2	X		X	X				
	Hydrovatus sp	X							
	Laccophilus sp1			X	X				
	Lancetes lanceolatus (Clark)		X						
	Macroporus sp1				X	X	X		
	Macroporus sp2						X		
	Necterosoma sp				X				
	Paroster sp		X		X		X		
	?*Rhantaticus* sp1				X				
	?*Rhantaticus* sp2	X							
(adults)	*Allodesus* sp	X	X	X	X	X	X	X	X
	Australphilus montanus Watts	X	X		X	X	X	X	
	Copelatus sp							X	
	Laccophilus sp2	X	X						X
Hydrophilidae (larvae)	*Berosus* sp1					X	X		
	Berosus sp2								X
	Laccobius sp		X						
(adults)	*Berosus* sp3		X						
Curculionidae (adult)	Sp							X	
Haliplidae (adult)	*Haliplus* sp	X							
Hygrobiidae (adult)	*Hygrobia australasiae* (Clark)			X	X	X		X	
Noteridae (adult)	Sp	X							
(LEPIDOPTERA)									
Pyralidae (larvae)	Sp		X						
MOLLUSCA GASTROPODA (PULMONATA)									
Planorbidae	*Physastra* sp								X
Species Richness (by site)		33	29	25	26	31	20	31	27

Total Species Richness (all sites): 90 species

* Drift Net

[a] site 6 sampled in autumn.